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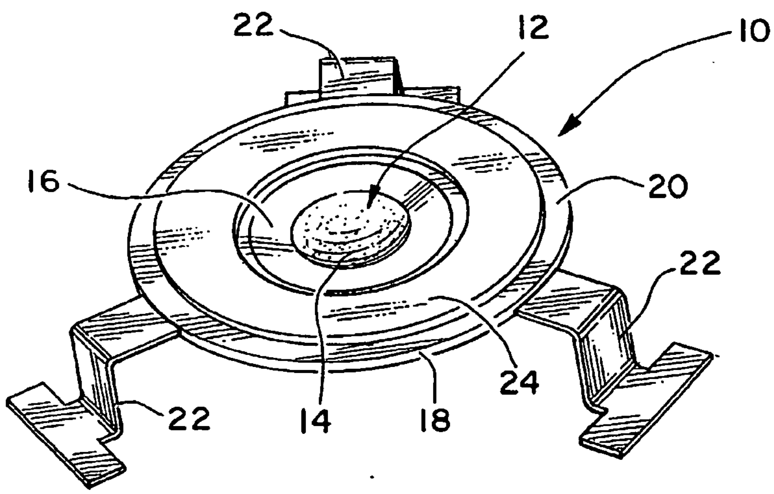
(54) Title: BASE ISOLATED NEBULIZING DEVICE AND METHODS



(57) Abstract: An aerosol generator (10) comprises a vibratable member (12) having a front, a rear (14), an outer periphery (16) and a plurality of apertures extending between the front and the rear. A support element is disposed about the outer periphery (16) of the vibratable member (12), and a vibratable element is configured to vibrate the vibratable member (12) at ultrasonic frequencies. An isolating structure (18) is coupled to the support element and is configured to couple the aerosol generator (10) to a support structure. The isolating structure (18) has a mechanical vibrational impedence that is sufficient to substantially vibrationally isolate the aerosol generator (10) from the support structure.

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BASE ISOLATED NEBULIZING DEVICE AND METHODS

BACKGROUND OF THE INVENTION

This invention is related generally to the field of aerosolization of liquids, and in particular to the aerosolization of liquids using an aerosol generator that operates at ultrasonic vibrational frequencies. More specifically, the invention relates to techniques for vibrationally isolating an aerosol generator that is connected to another structure, such as the housing of an aerosolization device, when aerosolizing a liquid.

Aerosolization of liquids is an important aspect of many businesses. For example, liquids are commonly aerosolized in connection with drug delivery, air humidification, deodorant or insecticide delivery, and the like. One exemplary way to aerosolize liquids is by supplying liquid to a vibratable member having a plurality of apertures and vibrating the vibratable member at ultrasonic frequencies. One way to vibrate the vibratable member is by use of a piezoelectric transducer. Such techniques are described in, for example, U.S. Patent Nos. 5,164,740; 5,938,117; 5,586,550; 5,758,637 and 6,085,740, the complete disclosures of which are herein incorporated by reference.

When vibrating such vibratable members at ultrasonic frequencies, there is a need to ensure that a maximum amount of the vibrational energy is transferred from the piezoelectric transducer to the vibratable member, rather than to some surrounding structure. Otherwise, performance losses or performance variations may occur because of the forces that are transmitted through the material which couples the aerosol generator to surrounding structures, such as the housing of an aerosolization device.

Hence, this invention is related to ways to maximize the amount of vibrational energy transferred to the vibratable member, thereby maximizing the efficiency of the aerosol generator. In this way, the repeatability and performance of the aerosol generator are enhanced, irrespective of the devices into which the aerosol generators are integrated.

SUMMARY OF THE INVENTION

The invention provides for the vibrational isolation of an aerosol generator from surrounding structures. In one embodiment, this is accomplished by the design of an aerosol generator that comprises a vibratable member having a front, a rear, an outer

periphery and a plurality of apertures extending between the front and the rear. A support element is disposed about the outer periphery of the vibratable member. A vibratable element is coupled to the support element and is configured to vibrate the vibratable member at ultrasonic frequencies. An isolating structure is coupled to the support element and is configured to couple the aerosol generator to a support structure, such as the housing of an aerosolization device. The isolating structure has a vibrational mechanical impedance that is sufficient to substantially vibrationally isolate the aerosol generator from the support structure. In this way, the aerosol generator may be operated at increased efficiencies and in a repeatable manner when coupled to surrounding structures.

Conveniently, the isolating structure and the support element may be integrated into a single component, thereby facilitating its manufacture. In one aspect, the isolating structure may comprise a plurality of arms that extend from the support element. These arms may have a wide variety of shapes and contours. For example, the arms may be bent, crimped, curved, or the like to facilitate vibrational isolation.

In another aspect, the isolating structure may comprise one or more elastomeric or plastic members. For example, the isolating structure may be constructed of an elastomeric or plastic washer. Conveniently, the washer may be coupled to the support element by forming tabs in the support element and inserting the washer between the tabs. As another example, the isolating structure may be constructed of a plurality of discrete elastomeric members or bellows that extend from the support element.

To facilitate vibrational isolation, the isolating structure may be configured so that it has a resonant frequency that is outside the operating range of the aerosol generator. Such an operating range for the aerosol generator may be about 50 kHz to about 250 kHz.

In a further aspect, the vibratable member may be dome shaped and include tapered apertures. Examples of such vibratable members are described in U.S. Patent Nos. 5,586,550, 5,758,637 and 6,085,740, previously incorporated by reference.

The invention further provides an exemplary method for aerosolizing liquids. Such a method utilizes an aerosol generator having a vibratable member with apertures and a vibratable element to vibrate the vibratable member. According to the method, liquid is supplied to the vibratable member and the vibratable element is used to vibrate the vibratable member at an ultrasonic frequency to eject liquid droplets through the apertures. During vibration, an isolating structure is used to substantially vibrationally isolate the aerosol

generator to enhance the operating performance of the aerosol generator. Further, the vibratable member may be vibrated at a frequency that is different from a fundamental frequency of the isolating structure to enhance the efficiency of the aerosol generator. As previously mentioned, a variety of isolating structures may be used to vibrationally isolate the aerosol generator from any surrounding structures. Such isolating structures also have resonant frequencies outside of the operating range of the aerosol generator.

In a further embodiment, the invention provides a method for forming an aerosol generator. According to the method, an isolating structure is stamped or coined out of a sheet of material. A vibratable member having a plurality of apertures is coupled to the isolating structure, and a vibratable element, such as a piezoelectric transducer, is coupled to the isolating structure or the vibratable member. The vibratable element is used to vibrate the vibratable member at ultrasonic frequencies while the isolating structure is used to vibrationally isolate the aerosol generator from surrounding structures. By forming the isolating structure in this way, the cost of producing the aerosol generator may be greatly reduced and the aerosol generator may be produced in higher volumes.

In one aspect, the isolating structure comprises an annular member and a plurality of arms extending from the annular member. In another aspect, the arms are bent or crimped after the isolating structure has been stamped. In a further aspect, the vibratable member is coupled across a central opening of the annular member, and the vibratable element comprises an annular piezoelectric element that is coupled to the annular member.

Another method for forming an aerosol generator uses a support element having an outer periphery. A plurality of tabs are formed in the outer periphery of the support element. This may be accomplished by making a pair of cuts in the support element and then bending the material between the cuts away from the support element. A vibratable member having a plurality of apertures is coupled to the support element, and a vibratable element is coupled to the support element or the vibratable member and is vibratable at ultrasonic frequencies. A gasket is coupled about the support element, with the gasket being received into the tabs. The gasket has a mechanical vibrational impedance that is sufficient to substantially vibrationally isolate the aerosol generator. Such a process is useful in producing an isolated aerosol generator in a time and cost efficient manner.

BRIEF DESCRIPTION OF THE DRAWINGS

Fig. 1 is a rear perspective view of one embodiment of an aerosol generator according to the invention.

Fig. 2 is a rear perspective view of an isolating structure of the aerosol generator of Fig. 1 prior to assembly of the aerosol generator.

Fig. 3 illustrates an aerosolization device having the aerosol generator of Fig. 1.

Fig. 4 is a front perspective view of another embodiment of an aerosol generator according to the invention.

Fig. 5 is a side perspective view of a further embodiment of an aerosol generator according to the invention.

Fig. 6 is a rear perspective view of yet another embodiment of an aerosol generator according to the invention.

Fig. 7 is a rear perspective view of still another embodiment of an aerosol generator according to the invention.

Fig. 8 is a rear perspective view of one particular embodiment of an aerosol generator according to the invention.

Fig. 9 is cross sectional view of another embodiment of an aerosol generator according to the invention.

Fig. 10 is a perspective view of a support element and an isolating structure of the aerosol generator of Fig. 9.

Fig. 11 is a perspective view of the support element of Fig. 10 prior to the formation of tabs that are employed to hold the isolating structure.

DESCRIPTION OF THE SPECIFIC EMBODIMENTS

The invention provides techniques and devices to vibrationally isolate an aerosol generator from surrounding structures to which the aerosol generator is coupled. In some cases, the surrounding structures will be the housing of an aerosolizer or nebulizer, or various structures within such devices. Such aerosolization or nebulization devices can have complex geometry's as well as complicated fluid delivery and packaging requirements that can affect the operation of the aerosol generator.

The aerosol generators of the invention may comprise a vibratable member having a plurality of apertures, such as an aperture plate, through which liquid droplets are

ejected and a piezo electric transducer to vibrate the aperture plate. The transducer is configured to vibrate the aperture plate at ultrasonic frequencies, typically within the range from about 50 kHz to about 250 kHz. Non-limiting examples aerosol generators utilizing such components are described in U.S. Patent Nos. 5,164,740; 5,938,117; 5,586,550; 5,758,637 and 6,085,740, incorporated herein by reference.

The aerosol generators of the invention utilize an isolation system that is designed to accommodate nearly all types of external interfaces to enhance the repeatability and performance of the aerosol generator. In this way, the aerosol generators may be placed into a wide variety of complex aerosolization or nebulization devices without significantly compromising their operation. The isolation systems have a mechanical vibrational impedance that prevents the force transmitted at the edge of the aerosol generator from reaching the surrounding structure. Such a phenomenon may be characterized as the transmissibility and is defined as the ratio of the force experienced by the surrounding structure to the force produced at the edge of the aerosol generator. According to the invention, the transmissibility is less than about 30%, more preferably less than about 20%, and most preferably less than about 10%. In some cases the transmissibility has been measured to be less than about 6% and at about 2% to 3% at resonance.

The isolation system may be constructed of either discrete or continuous elements and may have a wide variety of shapes and sizes. For example, the isolation system may be constructed of thin metals arms, elastomer bushings, plastic legs, elastomer edges, and the like. Types of materials that may be used to construct such elements include silicone, urethane, elastomers, thin or curved metals, and the like.

The isolating systems of the invention are also configured to have a resonant frequency that is outside of the operating frequency of the aerosol generator. In this way, the isolating structure does not resonate during operation of the aerosol generator, thereby enhancing the performance and repeatability of the aerosol generator.

Another feature of the invention is that the isolating systems may be incorporated into the aerosol generators in such a way that the aerosol generators may be fabricated in high volumes and at reasonable costs. This may be accomplished, for example, by utilizing an isolating structure to both vibrationally isolate the aerosol generator and to support the aperture plate. Such isolating structures may conveniently be formed by stamping, coining, molding, and the like.

Referring now to Fig. 1, one embodiment of an aerosol generator 10 having an isolating system will be described. Aerosol generator 10 comprises a vibratable member 12 having a front (hidden from view), a rear 14 and an outer periphery 16. Although not shown, vibratable member has a plurality of apertures that taper from rear 14 to the front. Examples of vibratable members that may be used with the invention are described generally in U.S. Patent Nos. 5,164,740; 5,938,117; 5,586,550; 5,758,637 and 6,085,740, incorporated by reference. As shown, vibratable member 12 is dome shaped in geometry. However, it will be appreciated that other shapes and sizes of vibratable members may be used, and the invention is not intended to be limited to a specific type of vibratable member.

Vibratable member 12 is coupled to an isolating structure 18 that also functions as a support member to support vibratable member 12. Isolating structure comprises an annular body 20 and a set of arms 22 that are used to couple aerosol generator 10 to another structure, such as the housing of an aerosolization device. Annular body 20 is secured about outer periphery 16 of vibratable member 12 so that the center of vibratable member is free to eject liquid droplets. Coupled to annular body 20 is an annular piezo electric element 24 that is used to vibrate vibratable member 12 when current is supplied to piezo electric element 24.

In use, arms 22 are employed to prevent the transmission of forces at the outer edge of body 20 from reaching surrounding structures so that aerosol generator 10 is substantially vibrationally isolated from any surrounded structures to which arms 22 may be coupled. In this example, arms 22 may be constructed of aluminum, steel, elastomers, plastic and the like and may have one or more bends to facilitate mounting of aerosol generator 10 to another structure and to prevent force transmission. Further, although shown with three arms, aerosol generator 10 may be constructed to have different numbers of arms, such a two, four, five, or the like. With such a construction, aerosol generator 10 may be operated in a repeatable manner, i.e., the aerosol generator is able to consistently produce droplets within a given size range and within a given range of flow rates. Further, this embodiment has shown to have a transmissibility at about 2% at resonance.

As shown in Fig. 2, isolating structure 18 may be stamped from a sheet of material. Once stamped, vibratable member 14 and piezo electric element 24 may be bonded to body 22. Arms 22 may also be bent to the desired shape. Such a process lends itself to high volume production at reasonable costs.

Referring now to Fig. 3, aerosol generator 10 is shown coupled to an aerosolization device 30. Device 30 comprises a housing 32 to hold the various components of aerosolization device 30. Housing 32 further includes a mouthpiece 34 and one or more vents (not shown) to permit air to enter into housing 32 when a user inhales from mouthpiece 34. Disposed within housing 32 is aerosol generator 10 of Fig. 1. However, it will be appreciated that any of the aerosol generators described herein may be placed into housing 32. Aerosol generator 10 is coupled to housing 32 by arms 22 that also serve as an isolating structure to vibrationally isolate aerosol generator 10 from housing 32 in a manner similar to that described herein.

Aerosolization device 30 further includes a canister 36 having a supply of liquid that is to be aerosolized by aerosol generator 10. Canister 36 may include a metering valve to place a metered amount of liquid onto aperture plate 16. Although not shown, a button or the like may be employed to dispense the volume of liquid when requested by the user.

Housing 32 includes an electronics region 38 for holding the various electrical components of aerosolization device 30. For example, region 38 may include a printed circuit board 40 which serves as a controller to control operation of the aerosol generator 10. More specifically, circuit board 40 may send (via circuitry not shown) an electrical signal to the piezoelectric element 24 to cause aperture plate 16 to be vibrated. A power supply P, such as one or more batteries, is electrically coupled to circuit board 40 to provide aerosolization device 30 with power.

Fig. 4 illustrates an alternative embodiment of an aerosol generator 70. Aerosol generator 70 comprises a vibratable member 72 having a front 74, a rear (not shown) and a plurality of apertures. Vibratable member 72 is coupled to a support member 76 that also supports a piezo electric element 78. Extending from support member 76 are a set of curved arms 80 that function as an isolating structure to vibrationally isolate aerosol generator from other structures to which arms 80 are coupled. Arms 80 may be constructed materials similar to those described in connection with Fig. 1. Further, although shown with only one curve, in some cases each arm may include multiple curves or bends to facilitate vibrational isolation of aerosol generator 70.

Fig. 5 illustrates another embodiment of an aerosol generator 82 having an alternative isolation system. Aerosol generator 82 is similar to aerosol generator 70 except

for the configuration of the arms. For convenience of discussion, similar elements will be referred to with the same reference numerals used in Fig. 4. Aerosol generator 82 utilizes a set of angled arms 84 that are connected to support member 76. Although shown with one angled bend, arms 84 may alternatively have multiple angled bends, that may or may not have the same angle of bend.

Figs. 6-8 illustrate further alternative embodiments of aerosol generators having different isolation systems. These aerosol generators are similar to aerosol generator 70 except for the isolating structure. For convenience of discussion, similar elements will be referred to with the same reference numerals used in Fig. 4. Fig. 6 illustrates an aerosol generator 88 having a set of tabs 90 that are connected to support member 76 and are used to vibrationally isolate aerosol generator 88 from surrounding structures to which tabs 90 are connected. Tabs 90 may be constructed of materials such as those described with previous embodiments, and may be more or less in number than shown in the drawing. Tabs 90 may optionally include mounting holes 92 to facilitate mounting of the tabs to another structure. In some cases, tabs 90 and support structure 76 may be formed together in an insert molding process as described generally in copending U.S. Patent Application No. ________, filed on the same date as the present application (attorney docket no. 16770-003500), incorporated herein by reference.

Fig. 7 illustrates an aerosol generator 94 having an elastomeric ring 96 that is coupled about the outer periphery of support member 76. Elastomeric ring 96 serves as an isolating structure to vibrationally isolate aerosol generator 94 from surrounding structures to which ring 96 may be coupled. Alternatively, a plastic material may be used to form ring 96.

Fig. 8 illustrates an aerosol generator 98 having a set of discrete elastomeric elements 100 that are disposed about the outer periphery of support member 76. These elements may be constructed of elastomeric or plastic materials similar to those described in Fig. 7 and may be more or less in number than three. Elements 100 are employed to vibrationally isolate aerosol generator 98 from surrounding structures to which elements 100 are connected.

Shown in Fig. 9 is a cross sectional view of an aerosol generator 110 having an isolation system and which may be manufactured in a time and cost efficient manner. Aerosol generator 110 is constructed of a support element 112 that is used to hold a vibratable member 114 having a plurality of apertures in a manner similar to that described

with other embodiments. As also shown in Fig. 10, support element 112 has a central aperture 116 across which vibratable member 114 is positioned and a circular outer periphery 118. Coupled to support element 112 is a vibratable element 120 to vibrate vibratable member 114 when aerosolizing a liquid.

Support element 112 may be manufactured by stamping support element 112 from a sheet as material such that is it in the shape of a disc or washer. As shown in Fig. 11, pair of cuts 122 and 124 are formed in support element 112 at the outer periphery 118 to form a set of tabs 126. Tabs 126 are then pressed or bent away from support element 112 to form a slot between tabs 126 and support element 112 as shown in Fig. 9. An isolating member 128 may then be inserted about outer periphery 118 by inserting isolating member 128 between tabs 126. Conveniently, isolating member 128 may comprise a resilient gasket that may be slipped between tabs 126. As with other embodiments, isolating member 128 may be used to vibrationally isolate the aerosol generator from surrounding structures.

The invention has now been described in detail for purposes of clarity of understanding. However, it will be appreciated that certain changes an modifications may be practiced within the scope of the appended claims.

WHAT IS CLAIMED IS:

1. An aerosol generator comprising:

a vibratable member having a front, a rear, an outer periphery and a plurality of apertures extending between the front and the rear;

a support element disposed about the outer periphery of the vibratable member;

a vibratable element coupled to the support element, the vibratable element being configured to vibrate the vibratable member at ultrasonic frequencies; and

an isolating structure coupled to the support element that is configured to couple the aerosol generator to a support structure, wherein the isolating structure has a vibrational impedance that is sufficient to substantially vibrationally isolate the aerosol generator from the support structure.

2. An aerosol generator as in claim 1, wherein the isolating structure and the support element are integrally formed together.

3. An aerosol generator as in claim 1, wherein the isolating structure comprises a plurality of arms extending from the support element.

4. An aerosol generator as in claim 3, wherein the arms have a contoured shape.

5. An aerosol generator as in claim 1, wherein the isolating structure comprises at least one elastomeric member.

6. An aerosol generator as in claim 5, wherein the isolating structure comprises a plurality of discrete elastomeric members extending from the support element.

7. An aerosol generator as in claim 1, wherein the isolating member is configured such that the ratio of forces transmitted to the support structure to forces at an outer edge of the support element is less than about 30%.

8. An aerosol generator as in claim 7, wherein the ratio is less than about 20%.

9. An aerosol generator as in claim 1, wherein the isolating structure has resonant frequencies that are outside of an operating frequency range of the aerosol generator.

10. An aerosol generator as in claim 9, wherein the operating frequency range is about 50 kHz to about 250 kHz.

11. An aerosol generator as in claim 1, wherein the vibratable member has a center portion containing the apertures, wherein the center portion is dome shaped in geometry, and wherein the apertures taper from the rear to the front.

12. An aerosol generator as in claim 1, wherein the support element comprises a disc member having a central aperture across which the vibratable member is positioned, and wherein the isolating structure comprises an annular gasket disposed about the disc member.

13. An aerosol generator as in claim 12, wherein the disc member has a circular outer periphery with a plurality of tabs, and wherein the gasket is inserted between the tabs.

14. An aerosolization device comprising:

a housing; and

an aerosol generator disposed within the housing, the aerosol generator comprising a vibratable member having a front, a rear, an outer periphery and a plurality of apertures extending between the front and the rear, a support element disposed about the outer periphery of the vibratable member, a vibratable element coupled to the support element, the vibratable element being configured to vibrate the vibratable member at ultrasonic frequencies, an isolating structure coupled to the support element, and operably connected to the housing, wherein the isolating structure has a vibrational impedance that is sufficient to substantially vibrationally isolate the aerosol generator from the housing.

15. A device as in claim 14, wherein the isolating structure and the support element are integrally formed together.

16. A device as in claim 14, wherein the isolating structure comprises a plurality of arms extending from the support element.

17. A device as in claim 16, wherein the arms have a contoured shape.

18. A device as in claim 14, wherein the isolating structure comprises at least one elastomeric member.

19. A device as in claim 18, wherein the isolating structure comprises a plurality of discrete elastomeric members extending from the support element.

20. A device as in claim 14, wherein the isolating member is configured such that the ratio of forces transmitted to the support element to forces at an outer edge of the support element is less than about 30%.

21. A device as in claim 20, wherein the ratio is less than about 10%.

22. A device as in claim 14, wherein the isolating structure has resonant frequencies that are outside of an operating frequency range of the aerosol generator.

23. A device as in claim 22, wherein the operating frequency range is about 50 kHz to about 250 kHz.

24. A device as in claim 14, wherein the vibratable member has a center portion containing the apertures, wherein the center portion is dome shaped in geometry, and wherein the apertures taper from the rear to the front.

25. An aerosol generator as in claim 14, wherein the support element comprises a disc member having a central aperture across which the vibratable member is positioned, and wherein the isolating structure comprises an annular gasket disposed about the disc member.

26. An aerosol generator as in claim 25, wherein the disc member has a circular outer periphery with a plurality of tabs, and wherein the gasket is inserted between the tabs.

27. A method for aerosolizing a liquid, the method comprising:

providing an aerosol generator comprising a vibratable member having a front, a rear, and a plurality of apertures extending between the front and the rear, and a vibratable element to vibrate the vibratable member;

supplying a liquid to the rear of the vibratable member; and

vibrating the vibratable member with the vibratable element to eject liquid droplets through the apertures while substantially vibrationally isolating the aerosol generator with an isolating structure.

28. A method as in claim 27, further comprising vibrating the vibratable member at a frequency that is different than a resonant frequency of the isolating structure, and wherein the vibratable member is vibrated at a frequency in the range from about 50 kHz to about 250 kHz.

29. A method as in claim 27, wherein the isolating structure comprises a plurality of arms extending from the aerosol generator, wherein the isolating structure is configured such that the ratio of forces transmitted to a support structure to forces at an outer edge of the aerosol generator is less than about 30%.

30. A device as in claim 27, wherein the isolating structure comprises one or more elastomeric members extending from the aerosol generator, wherein the elastomeric member has a mechanical vibrational impedance to substantially vibrationally isolate the aerosol generator.

31. A method for forming an aerosol generator, the method comprising:

stamping an isolating structure from a sheet of material;

coupling a vibratable member to the isolating structure, the vibratable member having a plurality of apertures; and

coupling a vibratable element to the vibratable member or the isolating structure, the vibratable element being vibratable at ultrasonic frequencies;

wherein the isolating structure has a mechanical vibrational impedance that is sufficient to substantially vibrationally isolate the aerosol generator.

32. A method as in claim 31, wherein the isolating structure comprises an annular member and a plurality of arms extending from the annular member.

33. A method as in claim 32, further comprising bending or crimping the arms after the stamping step.

34. A method for forming an aerosol generator, the method comprising:

providing a support element having an outer periphery;

forming a plurality of tabs in the outer periphery of the support element;

coupling a vibratable member to the support element, the vibratable member having a plurality of apertures; and

coupling a vibratable element to the support element or the vibratable member, the vibratable element being vibratable at ultrasonic frequencies;

coupling a gasket about the support element, with the gasket being received into the tabs, wherein the gasket has a mechanical vibrational impedance that is sufficient to substantially vibrationally isolate the aerosol generator.

35. A method as in claim 34, wherein the tabs are formed by making a pair of cuts in the support element and bending the material between the cuts away from the rest of the support element.

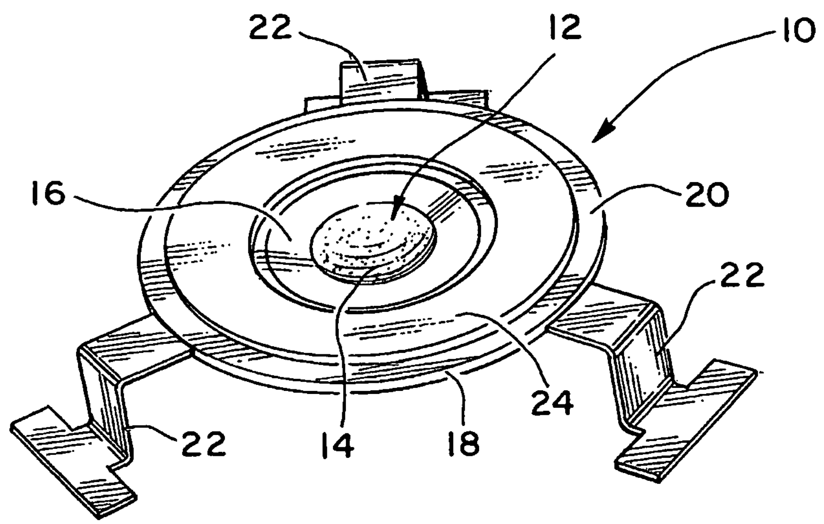


Fig. 1

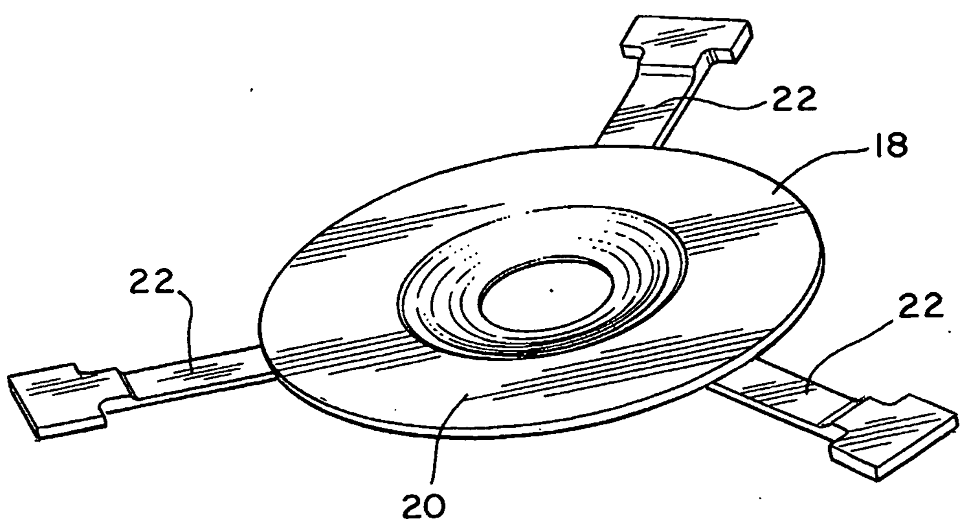


Fig. 2

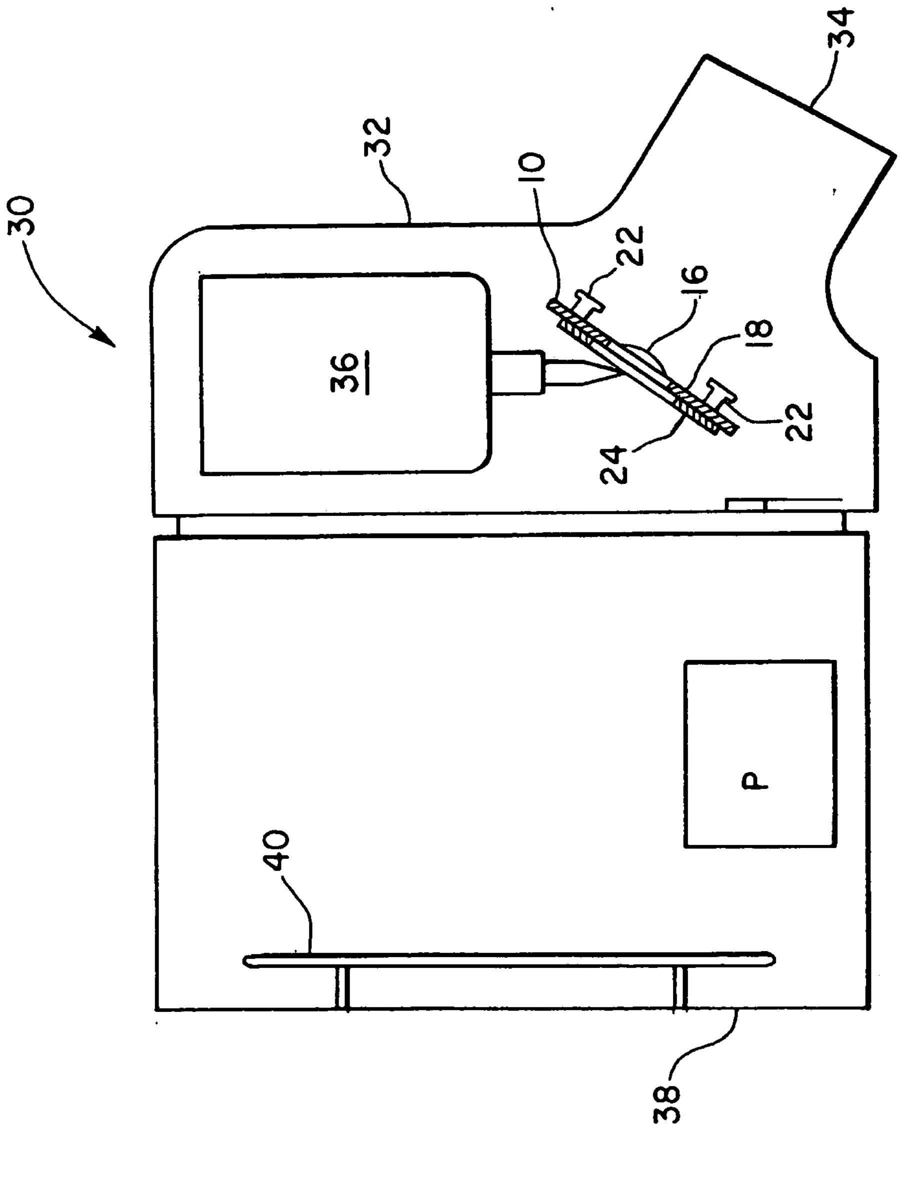
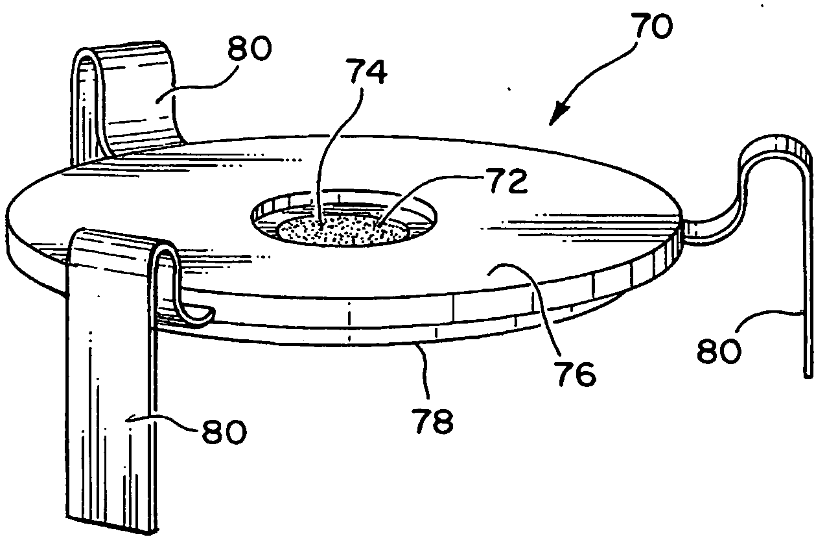


Fig. 3

Fig. 4



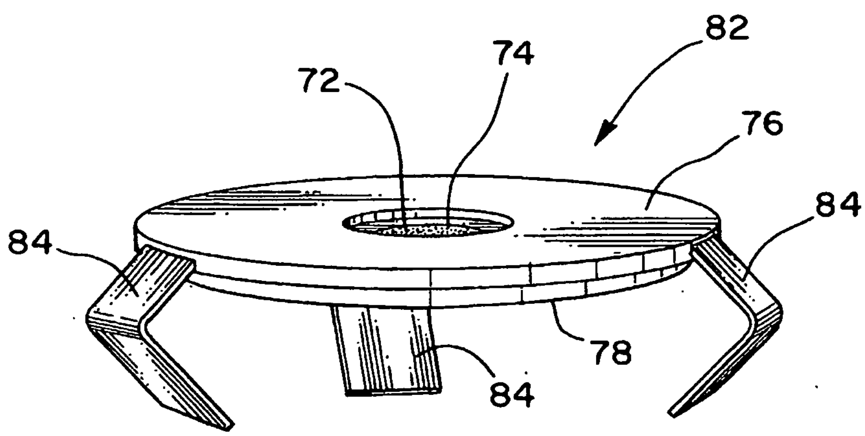


Fig. 5

Fig. 6

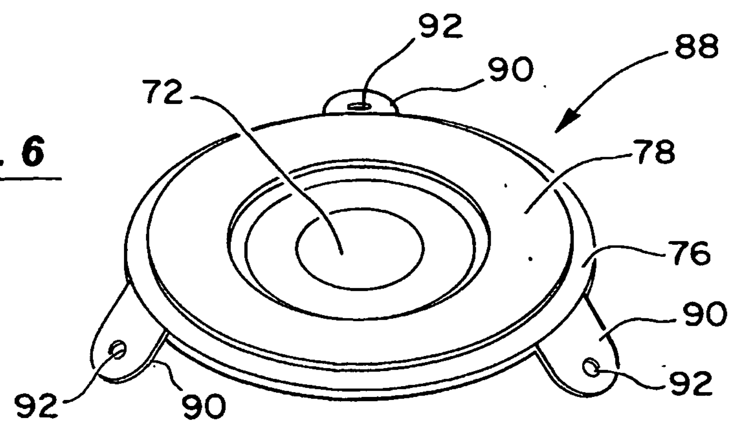


Fig. 7

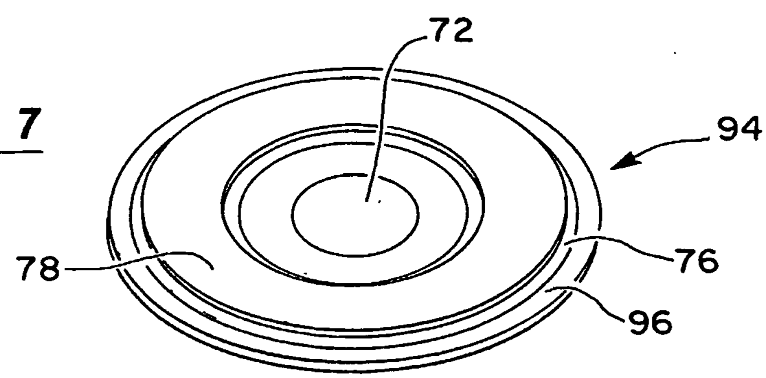


Fig. 8

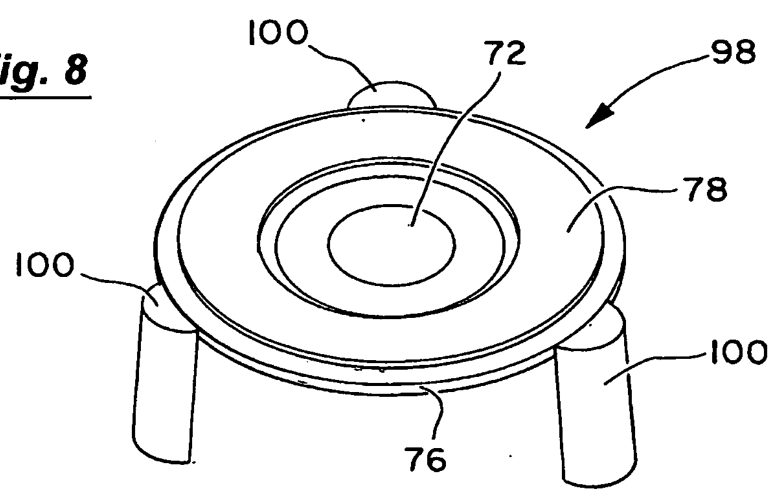


Fig. 9

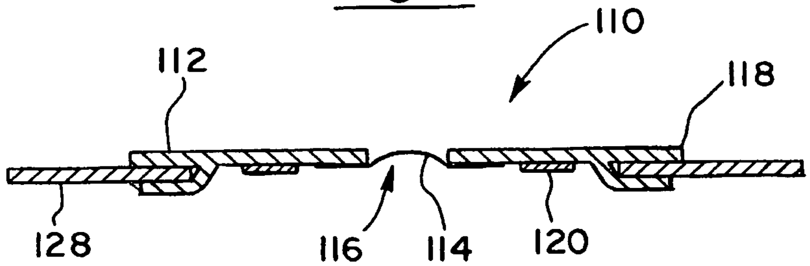


Fig. 10

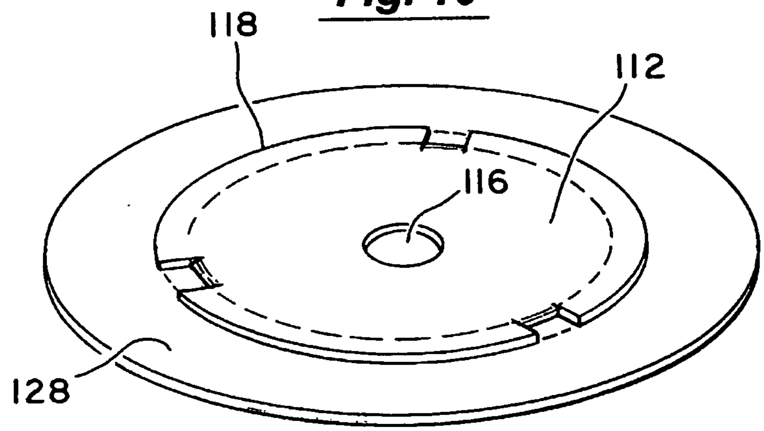
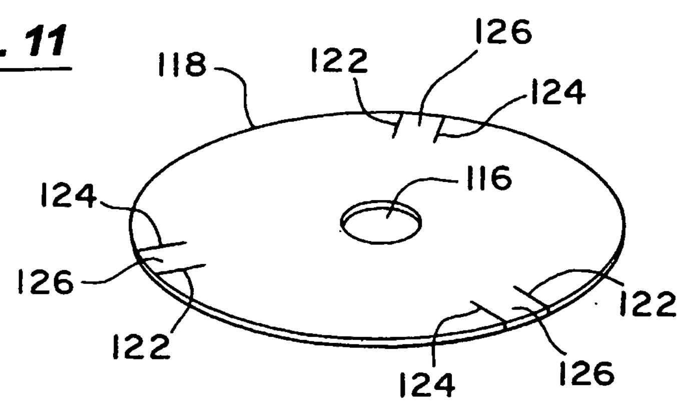


Fig. 11



INTERNATIONAL SEARCH REPORT

International application No.
PCT/US02/14208

A. CLASSIFICATION OF SUBJECT MATTER
IPC(7) : B05B 1/08
US CL : 239/102.1, 102.2
According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
U.S. : 239/102.1, 102.2

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched
none

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)
EAST

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X --- Y	US 5,657,926 A (TODA) 19 AUGUST 1997, SEE ENTIRE DOCUMENT.	1, 14, 27, 31 ----------- 2, 5-13, 15, 18-26, 28-30, 34-35

☐ Further documents are listed in the continuation of Box C. ☐ See patent family annex.

* Special categories of cited documents:

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier application or patent published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

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"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
25 June 2002 (25.06.2002)	12 JUL 2002
Name and mailing address of the ISA/US Commissioner of Patents and Trademarks Box PCT Washington, D.C. 20231 Facsimile No. (703)305-3230	Authorized officer J. Hurley for Lisa A. Douglas Telephone No. (703) 308-0861